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(71) Applicant
Donald Ian Guy MacLeod,
41 Phelps Street,
Geraldton, State of
Western Australia,
Commonwealth of
Australia
(72) Inventor
Donald Ian Guy MacLeod
(74) Agents
Kilburn and Strode,
30, John Street, London,
WC1N 2DD

(54) Submersible hydraulic bore and well pump

(57) A submersible hydraulic bore and well pump comprises a two-chamber cylinder with upper and lower chambers formed by an upper and a lower cylinder connected together to be coaxial and coextensive, and coupled pistons in these and valves, the assembly being so arranged that the upper cylinder 2 is a slave cylinder and the lower cylinder 3 is a working cylinder by connecting the slave cylinder at an upper end to a delivery pipe 4 and at a lower end to a pressure line 26 adapted to be connected to a remote master actuating device so that when no pressure or negative pressure is exerted on the fluid in the pressure line by the master actuating device the head of water in the delivery pipe forces the piston 5 in the slave cylinder down to similarly move the piston 6 in the lower working cylinder down through liquid admitted to the bottom of the said lower cylinder through a foot valve 21 and port in the bottom of the lower cylinder, but when pressure is exerted on the pressure line to move the piston in the upper cylinder upwards the lower piston discharges fluid from the lower cylinder through a hollow connecting rod 7 joining the pistons into the upper cylinder above the double-acting piston and thence up the delivery pipe.

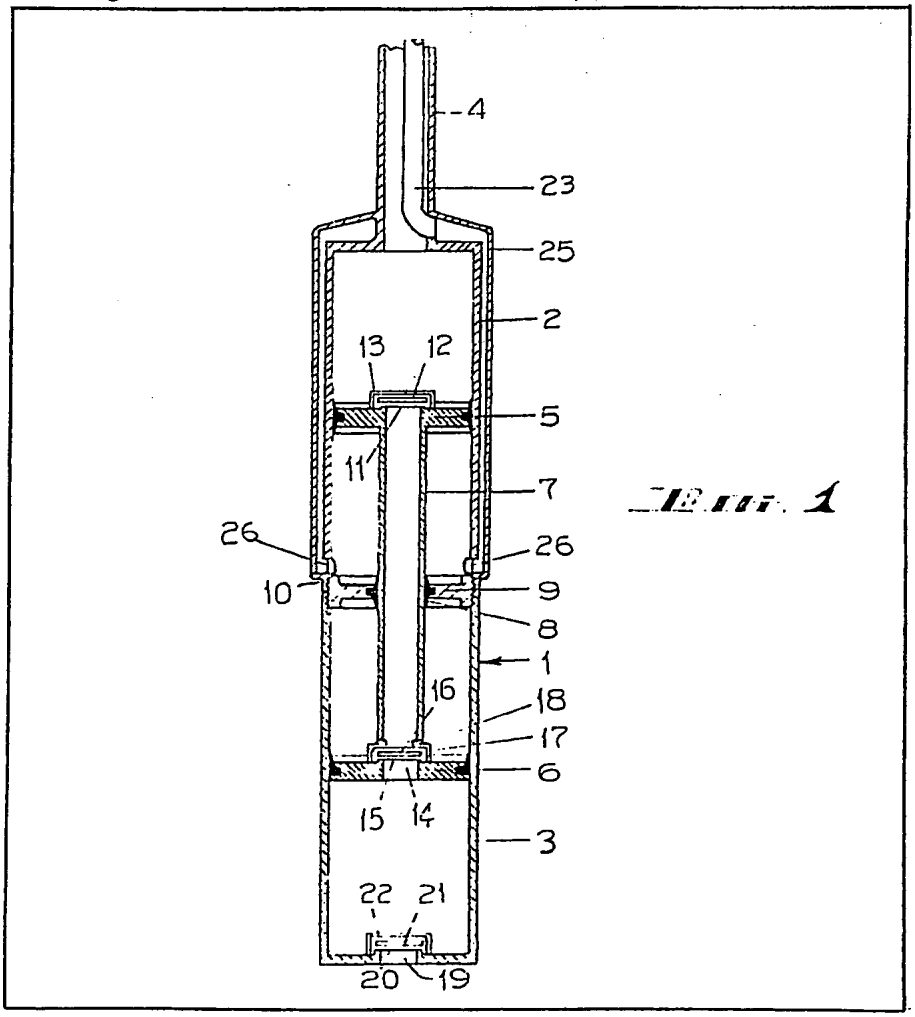


Fig. 1

GB 2 100 362 A

The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

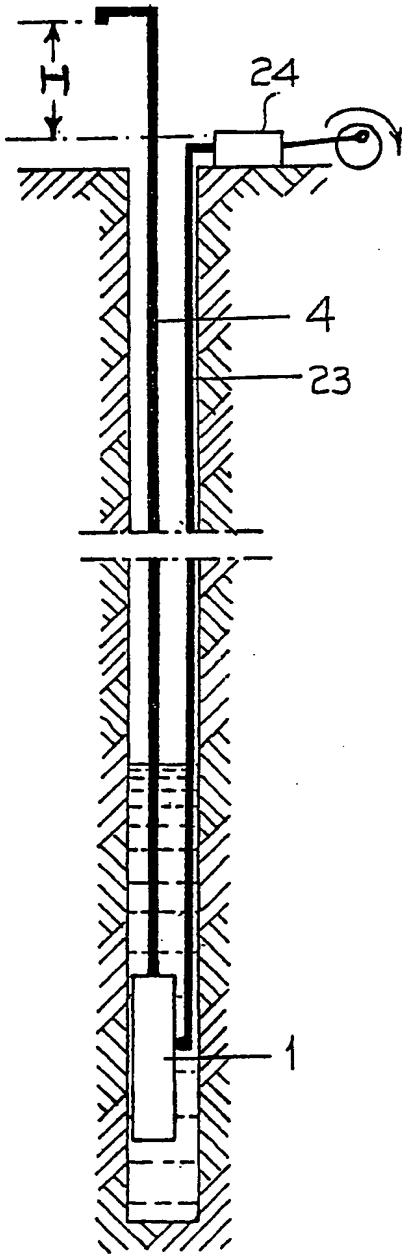
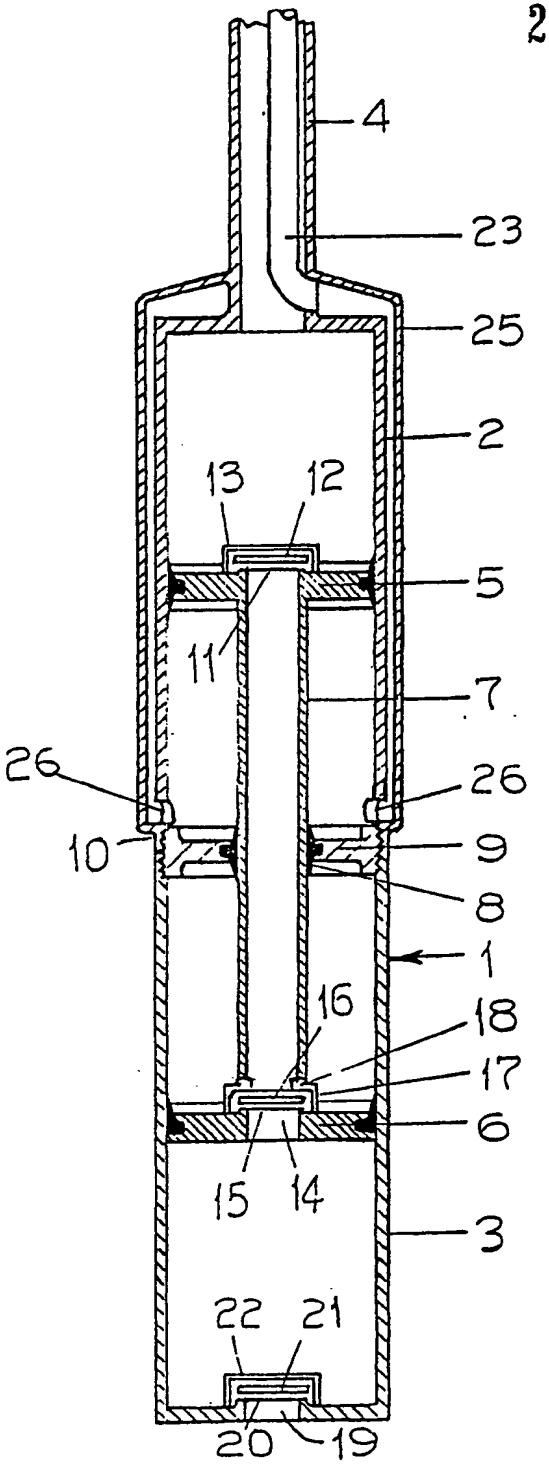

H
24
4
23
1

FIG. 2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23
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FIG. 1

SPECIFICATION

Submersible hydraulic bore and well pump

This invention relates to a submersible hydraulic bore and well pump and in particular relates to a pump of the type in which the pumping which lifts the water from the bore or well is disposed at the bottom of the bore well and is actuated by remote means at the surface of the bore or well through a water column.

It is well known to use mechanical connection between the pump at the bottom of the bore or well and an oscillatory mechanism at the top of the bore or well, and it is also known to use a hydraulic transmission line between a pump at the top of the bore or well and a slave pump at the bottom of the bore or well below the water line as is instanced by earlier patent taken out by me which is No 256, 593, and also a later patent application filed in the Commonwealth of Australia under No PD3229/78 lodged on 2 February 1978 on which a complete specification was lodged on 30 January 1979 under No 43780/79.

The present invention follows generally the form of device described in the specification of No 43780/79 aforesaid which involves a rearrangement of the various pumping chambers to achieve a simpler and better construction.

In the earlier form of the device the slave cylinder which was adapted to be immersed in the water which was to be pumped to a higher level had a double-acting piston in its cylinder, which cylinder connected to a delivery line of lesser internal cross-sectional area than the cylinder, which line projected upwards from, and was in communication with, the top of the cylinder and included an elevated discharge end, a second piston being positioned in a cylinder extending upwardly from the slave cylinder to form part of the delivery line which was coupled to move with the slave piston, the second piston having a one-way valve therein to allow water flow upward only through the valve in the second piston.

A one valve was arranged to admit water to the space in the cylinder beneath the second piston. A pressure line connected the inside of the master cylinder with that of the slave cylinder opposite to the delivery line whereby movement in one direction of the master piston was transmitted through fluid in the pressure line cylinder to the slave piston and the movement of the slave piston in the opposite direction was transmitted through the fluid in the pressure line to the master piston to return the master to the piston.

According to the present invention a submersible hydraulic bore and well pump comprises a two-chamber cylinder with upper and lower chambers formed by an upper and a lower cylinder connected together to be coaxial and coextensive, and coupled pistons in these and valves, the assembly being so arranged that the upper cylinder is a slave cylinder and the lower cylinder is a working cylinder by connecting the slave cylinder at an upper end to a delivery pipe and at a lower end to a pressure line adapted to be connected to a remote master actuating device so that when no pressure is exerted on the fluid in the pressure line by the piston of the master actuating device the head of water in the delivery pipe forces the piston in the slave cylinder down to similarly move the piston in the lower working cylinder down through liquid admitted to the bottom of the said lower cylinder through a foot valve and port in the bottom of the lower cylinder, but when pressure is exerted on the pressure line to move the piston in the upper cylinder upwards the lower piston discharges fluid from the lower cylinder through a hollow connecting rod joining the pistons into the upper cylinder above the double-acting piston and thence up the delivery pipe.

According to a preferred form the submersible hydraulic bore and well pump comprises a two-compartment cylinder formed of an upper slave cylinder and a lower working cylinder arranged co-extensively and coaxially and joined at a dividing wall separating the spaces defined by the two cylinders, a delivery pipe communicating with the space within the said upper cylinder at the closed end of the upper cylinder remote from the said dividing wall, a pressure line also communicating with the space within the said upper cylinder at the end adjacent to the dividing wall, a double-acting piston in the upper cylinder, a lifting piston in the lower cylinder arranged to lift water in the lower cylinder, a hollow connecting rod joining the two pistons with the hollow communicating with the space in the said upper cylinder above the said double-acting piston and with the space in the lower cylinder both above and below the lifting piston, the connecting rod passing through a double-acting seal secured in the dividing wall, and a series of valves, one to prevent downward flow at the top into the hollow connecting rod, one to prevent downward flow through a port through the lifting piston, and one to prevent downward flow through a port disposed in the closed lower end of the lower cylinder, the communication between the hollow connecting rod and the space in the lower cylinder above the lifting piston being by a port in the hollow connecting rod positioned at the lifting piston.

To enable the invention to be fully understood, an embodiment will now be described with reference to the accompanying drawings in which:

Figure 1 is a longitudinal sectional view of the mechanism of the preferred form, and

Figure 2 is a schematic view showing how the invention may be applied.

According to the present invention a double-compartment cylinder 1 is used at the bottom of the bore or well and comprises an upper slave cylinder 2 and lower working cylinder 3 arranged to be coextensive and coaxial, the upper cylinder 1 communicating at its top with the delivery pipe 4 which extends up the well or bore and this cylinder has within it an upper double-acting piston 5, that is a piston arranged to prevent pressure fluid passing it from either side, which is connected with a lower piston 6 which is arranged to lift water by having a

seal such as the wellknown pump bucket washer, the piston 6 being positioned in the lower working cylinder 3 by means of a hollow connecting rod 7 which passes through a double-acting seal 8 in a dividing wall 9 between the upper cylinder and the lower cylinder, the dividing wall 9 being externally screw-threaded at 10 to be engaged by an internal thread at the bottom of the upper cylinder 2 and an internal thread at the top of the lower cylinder 3.

The double-acting piston 5 in the upper cylinder 2 has the connecting rod 7 opening through it to form a seat 11 on which is a one-way valve 12 which opens upwardly but seals off downward flow from the upper part of the upper cylinder 2 through the hollow connecting rod 7, a cage 13 locating the valve 12. The piston 6 in the lower cylinder 3 has an aperture 14 through it which registers with a seat 15 and has a one-way valve 16 adapted to seat on it to prevent downward flow through the piston 6 in the lower cylinder 3, but immediately above this one-way valve is a cage 17 which locates the valve 16 and at the same time connects the hollow connecting rod 7 to the piston 6, the cage forming ports 18 which place the hollow of the connecting rod 7 into communication with the inside of the cylinder 3 above the piston 6.

The lower working cylinder 3 is also provided with an intake port 19 having a seat 20 which accommodates a foot valve 27 in a cage 22, which foot valve 21 allows flow only into part of the lower cylinder below the piston 6 from the water in the bore or well.

In this way a very simple arrangement results which has an upper double-acting piston 5 connected to a lower single-acting piston 6 by means of the hollow connecting rod 7. This assembly allows the valves 12 and 16 associated with the hollow connecting rod 7 to be of simple design as is also the foot valve 21 at the base of the lower cylinder to similarly take a simple form.

A pressure line 23 is connected from the lower end of the upper cylinder 2 to the master unit cylinder 24 at the surface, which master unit can be of similar construction to that described in the previously referred to patent specification, and simply consists of a piston and cylinder arranged to displace liquid in the pressure line when the piston is reciprocated.

The pressure line 23 opens to a space between the upper cylinder 2 and a sleeve 25, which space communicates with the inside of the cylinder 2 at the lower end through ports 26.

In Figure 1, "H" indicates the difference in head between the delivery pipe and the pressure line.

The action of the pump when applied in pumping water from a well is as follows:

When water is forced down the pressure line 23 by the master unit 24 at ground level, the water enters the lower part of the upper slave cylinder 2 and acts against the double-acting piston 5 to push the piston 5 upwards, carrying with it the hollow connecting rod 7 and the piston 6 in the lower cylinder 3, causing the piston 6 in the lower cylinder to allow water to flow into the lower part of the lower cylinder 3 thorugh the foot valve 20 at the base of it, or to draw water in, so that when the pistons 5 and 6 reach the top of their stroke, both the upper cylinder and the lower cylinder are full of water below the respective pistons.

It should be explained that, in the form illustrated herein, as in the earlier referred to Patent Specification, the delivery pipe 4 projects some distance above the top of the pressure line 23 so that when the master piston at the surface is not forcing water downwardly, the greater pressure head in the delivery pipe 4, as compared to the lower pressure head as in the pressure line 23, forces the valve 12 to close and the water pressure on top of the upper double-acting piston 5 then forces both the pistons 5 and 6 which are joined by the hollow connecting rod 7 to move downwards, but during such downward movement the valve 15 at the base of the hollow connecting rod 7 adjacent to the piston 6 in the lower cylinder 3 allows this piston 6 to move freely through water in the lower cylinder 3, and because the intake port 19 is closed by the foot valve 21 in the base of the lower cylinder 3 the water is trapped in the lower cylinder and the piston 6 merely moves down through the water in the lower part of the lower cylinder 3, displacing the water through the valve 16 at the lower end of the hollow connecting rod 7 and the ports 18 in the hollow connecting rod.

During this stroke therefore the lower cylinder 3 remains full of water and the piston 6 simply moved down through the water in the cylinder.

During this stroke also the water in the pressure line 23 has been forced upwardly because the water beneath the piston 5 in the upper cylinder 2 cannot escape from the upper cylinder other than by flowing out the pressure line 23. When the two pistons 5 and 6 reach the bottom of their stroke water in the pressure line 24 is again displaced downwardly by the master surface unit and it now pushes the double-acting piston 5 upwardly in the upper cylinder 2, carrying with it the hollow connecting rod 7 and the lower piston 6 in the lower cylinder 3. When this occurs the valve 16 at the lower end of the hollow connecting rod 7 closes so that now the water in the upper part of the lower cylinder 3 is forced through the ports 18 into the hollow connecting rod 7 and lifts the valve 12 at the top of the hollow connecting rod 7 so that displacement of water now takes place into the delivery pipe 4 of that water above the double-acting piston 5 in the upper cylinder 2 as well as that water between the piston 6 in the lower cylinder 3 and the dividing wall 9 through which the hollow connecting rod passes.

From the foregoing it will be realised that on the down stroke the piston 6 in the lower cylinder moves freely through the fully water charged lower cylinder 3 while the water from the delivery pipe 4 moves down to force the double-acting piston 5 in the upper cylinder 2 down and water in the pressure line 23 up, so that there is a relatively

balanced head on the two sides of the double-acting piston 5, in the upper cylinder 2, but as explained earlier herein, the delivery pipe 4 is actually taken to a higher level that the pressure line 21 to increase the head on the top of the double-acting piston 5 with the result that the piston is forced down by differential pressure and is followed by a corresponding motion of the master piston of the surface unit 24 which provides the downward pressure on the water in the pressure line 23.

This as said takes place because at this stage the valve 12 at the top of the hollow connecting rod 7 is closed by the pressure from the delivery pipe 4 and the piston 6 in the lower cylinder 3 simply moves through the water which was drawn into the lower cylinder 3 on the up stroke, but when the bottom of the stroke of the pistons 5 and 6 is reached and the pressure line 23 again has the water within it forcibly displaced downwardly by the master piston at the surface unit 24 the lifting action of the two piston 5 and 6 forces both the water from above the double-action piston 5 in the upper cylinder 2 and the piston 6 in the lower cylinder 3 up through the delivery pipe 4 so that a greater volume of water is lifted than is lost by downward movement in the delivery pipe on downward movement of the pistons 5 and 6.

This then results in a simple and effective arrangement where water is taken in to the lower cylinder through a foot valve at the base of the cylinder and is at the appropriate time discharged together with the water from above the piston in the upper cylinder.

Any form of valve may be used but generally ordinary bucket valves confined in cages are suitable.

The porting in the hollow connecting rod must of course be adjacent to the valve which seals off flow through the piston in the lower cylinder on its up stroke and the porting must ensure that no flow takes place through the dividing wall seal through which the hollow connecting rod passes.

Instead of using a pressure head "H" to give a return stroke loading on the piston 5 as described with reference to the preferred embodiment, a double-acting master unit 24 could be used, such as a diaphragm pump, whereby to give a pressure differential at the top of the pressure line 23 in relation to the delivery pipe 4 to cause the water in the delivery pipe 4 to free the portion 5 downwardly.

CLAIMS

1. A submersible hydraulic bore and well pump comprising a two-chamber cylinder with upper and lower chambers formed by an upper and a lower cylinder connected together to be coaxial and coextensive, and coupled pistons in these and valves, the assembly being so arranged that the upper cylinder is a slave cylinder and the lower cylinder is a working cylinder by connecting the slave cylinder at an upper end to a delivery pipe and at a lower end to a pressure line adapted to be connected to a remote master actuating device so that when no pressure or negative pressure is exerted on the fluid in the pressure line by the master actuating device in the head of water in the delivery pipe forces the piston in the slave cylinder down to similarly move the piston in the lower working cylinder down through liquid admitted to the bottom of the said lower cylinder through a foot valve and port in the bottom of the lower cylinder, but when pressure is exerted on the pressure line to move the piston in the upper cylinder upwards the lower piston discharges fluid from the lower cylinder through a hollow connecting rod joining the pistons into the upper cylinder above the double-acting piston and thence up the delivery pipe.

2. A submersible hydraulic bore and well pump comprising a two-chamber cylinder formed of an upper slave cylinder and a lower working cylinder arranged coextensively and coaxially and joined at a dividing wall separating the spaces defined by the two said cylinders, a delivery pipe communicating with the said space within the said upper cylinder at the closed end of the said upper cylinder remote from the said dividing wall, a pressure line also communicating with the said space within the said upper cylinder at the end adjacent to the said dividing wall, a double-acting piston in the said upper cylinder, a lifting piston in the said lower cylinder arranged to lift water in the said lower cylinder, a hollow connecting rod joining the two said pistons with the hollow communicating with the space in the said upper cylinder above the said double-acting piston and with the space in the said lower cylinder both above and below the said lifting piston, said connecting rod passing through a double-acting seal secured in the said dividing wall, and a series of valves, one to prevent downward flow into the said hollow connecting rod, one to prevent downward flow through a port through the said lifting piston, and one to prevent downward flow through a port disposed in the closed lower end of the said lower cylinder, said communication between the hollow connecting rod and the space in the said lower cylinder above the said lifting piston being by a port in the said hollow connecting rod positioned at the said lifting piston.

3. A submersible hydraulic bore and well pump according to claim 2 characterised in that two of the said valves are arranged one to engage a seat on the said double-acting piston surrounding an aperture communicating with the said hollow connecting rod, and another to engage a seat surrounding an aperture through the said lifing piston communicating with the said hollow connecting rod when the said valve is open.

4. A submersible hydraulic bore and well pump according to claim 3 characterised in that the second said valve is disposed in a cage joining the lower end of the said hollow connectig rod to the said lifting piston, said cage forming a port to

allow liquid to flow from the space in the said lower cylinder above the said piston into and out of the said hollow connecting rod.

5. A submersible hydraulic bore and well pump constructed and operating substantially as described and illustrated.

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